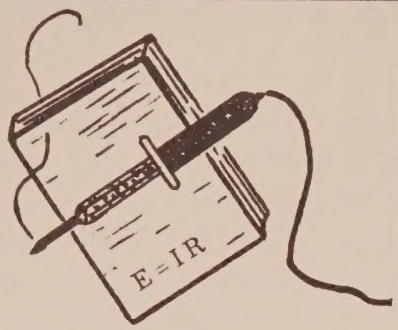


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Volume 5, No. 4 July-August, 1967


# W6GD ANTENNA NOTES

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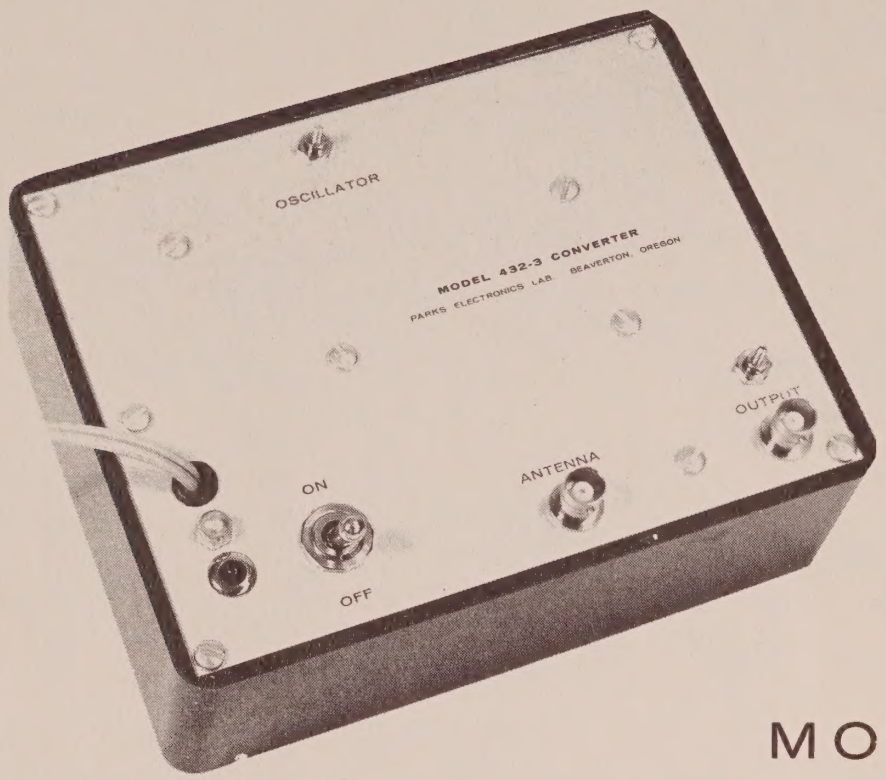


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# A SERIES OF ARTICLES ON ANTENNAS

As you are probably well aware of the fact that we have long proclaimed that the weakest link in most ham VHF stations is the antenna, you can probably imagine the personal satisfaction we obtain from bringing you information to help you improve that weak link. Publication of antenna contest results should have opened the eyes of some of you to the terrible inadequacies of many commercial antennas. The winners of these contests have invariably been the extended-expanded colinears. The man responsible for the design of this type antenna was the late Oliver Wright. He had written quite a bit of material about antennas in the form of notes, which we are publishing with the permission of Mrs. Wright. There will be references to figures or diagrams not given in the same issue. You will have to bear with us there, awaiting the next issue because we prefer to publish the notes just as they were written. Mr. Wright worked at Stanford Research Institute. Hank Olson, W6GXN, has worked at S.R.I. for a number of years and knew Oliver Wright well. We asked Hank to write the introduction to this series of articles on antennas. LP

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Oliver Wright, W6GD, was involved in amateur radio from its very early years, and contributed to the radio art throughout his life. As 6GD, Oliver was shown in QST with the first amateur mobile rig in the early 1920's. [1](See QST for May, 1964, p. 76)

Oliver worked for the American Telephone and Telegraph Co., principally in California and New Jersey. In New Jersey he was associated with the club station W3BBO, which was noted for its huge antenna farm and potent signals on the H.F. ham bands. During the course of his work for A.T.& T., Oliver worked with a number of the well-known names in the antenna field like Sterba and Beverage.

In the San Francisco Bay area, as W6GD, Oliver's amateur activities were almost entirely on 2 meters (occasionally on 10 meters when it was "open" to New Jersey). His main interest was in VHF antennas and their measurement.

Oliver was a frequent speaker at the local amateur radio clubs in the bay area, and one of the initiators of the VHF Antenna Measuring Contests that are now an annual event in California. In memory of Oliver Wright, W6GD has been adopted as the call of the UHF Society in northern California, the organization which conducts the annual antenna measuring contests.

Oliver Wright died in the spring of 1956, leaving his "Antenna Notes" as a legacy for the surviving VHF enthusiasts. Copies of the Antenna Notes have been unavailable for many years, but in great demand. Finally, now they are to be reprinted in their original form in the VHFER magazine. H. Olson, W6GXN

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# VHF ANTENNA NOTES -- WITH THE ACCENT ON TWO METERS

by Oliver Wright, W6GD

These notes have been prepared with the hope that they will be of some help to amateurs intending to build and operate VHF antennas. While the techniques and dimensions presented deal particularly with the 2 meter band, the basic principles involved apply to the other bands in general. The illustrated examples are based solely on 2 meter dimensions, but may be adapted to the other bands, within reason. Arrangement of this material is in note form rather than as a narrative, and is of necessity very abbreviated. This material is the result of personal study, experimentation, operation and general experience with numerous types of antennas on frequencies from 4 to 148 mc.

1. Antenna dimensions given in these notes are based on the actual wavelength in free space at 146mc, which length equates to 81 inches. Element lengths are modified by the diameter-to-length ratio, end loading etc., and are mainly based on 1/4" diameter. Element diameters greater than 1/4" will usually require a shortening in the length of the driven elements. Smaller diameters will not be affected appreciably. It is not correct to change both radiator and parasitic element lengths by the same amount when varying the diameter. The new lengths for the parasitic elements must be determined experimentally.

2. Open wire lines, and this includes twin-lead, should be treated with a certain amount of respect. For best results they should be separated by at least five times their own spacing from other lines or objects insofar as practicable. Don't use twin-lead as casually as lamp cord.

Transpositions in open wire lines are not necessary, other than for correct phasing between radiators. In the main line from the transmitter they serve no particularly useful purpose. If they distort the shape or spacing of the line, or require extra insulators (to achieve these transpositions) they will most likely cause additional line irregularities. When turning corners in open wire lines, changes as abrupt as 90 degrees are permissible if the line is rolled on its side to permit banking around the turn, thus maintaining equal wire lengths on each side. Excess insulation or hardware on the line at such a point should be avoided. Wherever possible avoid the use of spreader insulators that are held in place with metal tie wires. They cause considerable wave reflection. Tie the insulators on with cord or else melt them onto the wire á la ladder line.

Any insulators on transmission lines, including stand-offs, should be used sparingly. Where there is a large standing wave on a line, insulators at current maximum points will have less effect than those at current minimum points. Excess insulators cause reflections due to capacitance, and to shunt leakage paths when wet or dirty.

3. When using "ladder line" it is desirable to remove two thirds of the insulators, leaving one every 18 inches, where possible. Such modified sections must then be pulled taut and kept that way. Where the line must be left slack do not remove any insulators. The 1 inch spaced 470 ohm line is preferable to that with closer spaced 300 ohm line which is more apt to become seriously deformed with handling and flexing. The wider spaced line, when properly handled, is more efficient than the twin-lead, having appreciably less attenuation loss and negligible radiation loss.

4. For coupling transmission lines to rotating antennas, one half wave and one full wave lengths of flat 300 ohm twin-lead work very satisfactorily, if they are not overloaded electrically. Use first grade line, such as Amphenol, Belden, G.E., etc. Before cutting be sure to allow for the proper velocity of propagation (VP). The manufacturers' figures on the VP are extremely close. The sections will withstand years of rotation if not abused. These lengths of line have a 1 to 1 impedance ratio from end to end, hence the twin-lead impedance drops out of the picture, even when wet. Care should be taken to prevent the section from winding up against the metal pole or there will be an irregularity. A plastic fender on the pole will prevent this.

5. Don't connect co-axial lines to balanced antennas or to sections of balanced transmission lines, without suitable baluns at the junction points. If you neglect the balun, the outer conductor of the co-ax will radiate as a single wire line; and very possibly the open wire section will become unbalanced and radiate. In some extreme cases it has been found that around 75% of the power may be radiated from such a line. Co-axial lines are extremely susceptible to this sort of thing. The outside of the outer conductor acts as an un-neutralized third wire. Balanced open wire lines are not immune if unsymmetrically coupled to a radiator.

6. There are many misconceptions about radiation from open wire lines. It is not necessarily true that there is an appreciable increase in radiation from a line as the standing wave ratio increases. If the standing wave ratio on a well balanced line increases from 1 to 1 to a value of 3 or 4 to 1, the percentage increase in line radiation is extremely small. An unbalance in line currents, both in amplitude and position, causes far more line radiation. In other words, a line that is apparently well terminated but that has a phase shift between the wires (other than the required 180 degrees) will radiate considerable more than a line having a 4 to 1 ratio, but with no unbalance or shift. See QST, January 1954, Page 44, for additional information on this. However the statement that co-axial lines do not radiate under any circumstances is not correct. See Section 5 of these notes.

7. At the best, grid-dip meters, antennascopes, micromatches, etc., indicate only that certain impedances exist at the point at which they are inserted. The accuracy of this indication is usually debatable at 2 meters; unless you have some extremely high grade lab equipment. They cannot indicate anything particularly useful about the operation of the antenna as a radiator, such as tuning of the parasitic elements, general phasing conditions, etc. A micromatch might show the SWR but the accuracy is doubtful at this frequency. It won't show the standing wave position on the line, which knowledge is quite necessary in making workmanlike termination adjustments.

8. To measure standing wave ratio (SWR) on an open wire line, use a pick-up loop with a series tuning condenser and a 1 amp. R.F. meter. See Fig 9d. This device, if properly built and used, will measure current standing waves, independently on each wire of a two wire line having two or more inches spacing. Another way is to use a small untuned pick-up loop with a series indicator such as a small tungsten filament lamp, or a diode and microammeter. See Fig 9a. Note that the indicating device is cut into the loop at its mid point. This also reads the current standing wave, with the point being measured found directly under the take-off point for the indicator. With the resonant circuit it is possible that there will be a slight displacement error in the indication of the wave position. To check this turn the equipment upside down on the line. Any error

found between the two positions should be divided by two. It is possible to build a similar device for use on ladder line, but the problem of sliding it along past the insulators, and avoiding actual contact between the wires, is a little complicated.

On co-axial lines the most accurate way to measure voltage standing waves is by the use of a vacuum tube voltmeter probe on a section of slotted line. This apparatus also indicates amplitude and position of the wave; but such a device is not very common. If a micromatch is used it should be carefully checked at 146 mc against such a line; at a lab if possible. Again remember that the micromatch cannot tell wave position.

One reasonably satisfactory way of establishing approximate standing wave values on co-axial lines which are to be connected eventually to balanced loads is as follows: Connect a test section of flat 300 ohm twin-lead to the load and find the wave position and amplitude. If necessary apply impedance correcting lines or stubs and adjust either for a flat line or for one with a known value of standing wave, using one of the untuned pick-up devices shown in the sketches. Certain ratios of standing waves indicate definite non-reactive impedances at points where the current wave reaches a maximum or minimum value, known as a "max" or a "min" point respectively. A 2 to 1 current SWR on a 300 ohm line indicates 150 ohms resistance at the current max point and 600 ohms resistance at the current max point would be 200 ohms, and this point would match the output of a half wave balun made of 52 ohm co-ax line.

Don't use a field strength meter as a method of adjusting SWR. You may be surprised to find how little correlation there is. The adjustments you make may simply be tuning the output circuit of your transmitter. The only way the SWR can be checked properly is on the line itself. When the line has been terminated in the proper manner then a field strength reading may be used as an indicator while the output circuit is readjusted for maximum value. If you can't get the most output this way you had better work over your output coupling circuit, because there is something wrong with it. A neon bulb is a very unreliable and crude SWR indication. Don't trust it.

9. Here is a method of matching an unknown balanced load to a balanced line.

A. Connect a 300 ohm twin-lead test line to the load. Make a test run on the line with the untuned pick-up loop, in the vicinity of the load. Locate the first current max point back from the load. (If it is less than about 7 inches from the junction of line and load look for the next max point back toward the transmitter.) See Fig. 8a.

B. Cut a piece of ladder line, or other suitable line (such as #12 wire spaced two inches) to the same electrical length as the distance from the load point back to the max point selected. Allow about 3 or 4 inches extra length for adjustments. This length has to be corrected for the different velocity of propagation on the two lines. The VP on the twin-lead is about 82%. (Consult the mfgr's tables for value of VP or determine it yourself by actual measurement between adjacent current min points one-half wave apart. The accuracy is increased depending upon how many half-wave points are measured.)

Assume that the distance back to the max point selected "happens" to be 25 inches, as measured on the twin-lead. 25 inches divided by 82% gives 30.5 inches. This is the approximate length of the ladder line (or equivalent) stub that we are going to

build and hang from the feed point on the antenna (our load), where the twin-lead was originally connected in (A) above. The ladder line's VP is almost 100%.

Make a strap-type sliding short to be placed on the ladder line, starting at the 30.5 inch point as a trial position. (Remember; the lengths quoted in this example were selected at random ) Fasten the twin-lead test line to the stub about 6-9 inches above the short, at point "B" , using small, homemade copper lugs (or equivalent bent around the wires. Keep them as small as possible. Clips cause too much irregularity.

C. Measure back one-half wave on the twin-lead test line from point "B", and mark point "X". 33.5 inches is a good value to use on 2 meters for all lines having around 82% VP. (With a little experience you can determine this point yourself from other measurements, as mentioned above.)

At point "X" the impedance seen when measuring will be the same as at point "B", which latter is not a convenient place to measure with this type of indicator. Hence "X" will be our test point.

D. What we are now attempting to do is to adjust the position of the sliding short at "C" on the stub so that the stub will present only a resistive load to the 300 ohm line. The value of the load depends upon the position at which the line taps on at "B". If we deliberately pick a spot where the impedance should be higher than 300 ohms we will get a current min point at "B", and at point "X".

E. NOW — If the min point is found to be between "X" and the stub, shorten the stub by sliding short "C" upward slightly, and try again. If the min is between "X" and the transmitter, lengthen the stub slightly by sliding "C" downward. Keep this up until the min point falls at "X". If the position of the current min point is not well defined during these adjustments move tap point "B" upward slightly. When the min point is satisfactorily set, lock the short in place, as you're now through with this particular adjustment. The final length of the stub "A-C" should be within a few inches of the computed value; 30.5 inches in this example.

F. Next — Move the tap point "B" down to a position where the standing wave effectively disappears. If you are going to use a 300 ohm line, the job is finished. If some other value of line impedance is to be used, you have a little more work. If a 470 ohm ladder line is to be used, move the twin-lead tap point "B" up higher than the 300 ohm point until the measured standing wave ratio is 1.57 to 1. That's the place the 470 ohm line should be attached.

If a 200 ohm impedance is going to be used (the output of a 4 to 1 step-up balun using 52 ohm co-ax line) move the tap point down below the 300 ohm adjustment until an SWR of 1.5 to 1 is obtained — That's it.

Remember; the position of the short is the same regardless of the impedance of the line from the transmitter. A change of frequency might call for a slight change in the position of the stub; but if it is tuned at 146 mc and soldered in place there won't be too much SWR at any place in the 2 meter band. Solder Tap point "B" also.

G. If the final distance from tap point "B" to point "A" is greater than 40 inches it would be well to shorten "A-B" by 40 inches and readjust for final values. This applies to section "A-B" only. Section "B-C" should remain the same. (Except for any minor adjustments.)

To become familiar with the use of this technique try it out on the extended full wave antenna shown in these notes. Clamp the antenna horizontally on top of a 6 foot step ladder (with the phasing line running directly upward to the radiators). Your answers should agree fairly closely with those given in these notes. When you gain a little experience with the use of the SWR measuring equipment, try using the method in the 1953 ARRL Handbook, Page 317, under "Stub Matching." This is another way of arriving at essentially the same answer as above. Since the stub in this case will be of the same material as all of the main line, the dimentions may differ slightly from those you determined above. As a further point of interest note that in our problem above, the actual stub is the section "B-C". Sections "X-B" and "B-A" are part of the main line. Standing waves are a reflection phenomenon; hence no adjustment that you can make at the transmitter, other than varying frequency, can change them.

10. When making termination adjustments on a 2 meter array it is satisfactory to place it on its back, facing straight up, on an 8 foot wooden step ladder. This minimizes ground effect on the elements and obviates a lot of climbing while making these adjustments. CAUTION — Don't bump into the elements while crawling around. They're your eyes!

11. Don't use an R.F. meter in the short on a tuning stub, for termination adjustments. This is an unreliable method. An R.F. meter in the transmission line, as an indication of relative output power into the line, is an excellent idea. If the frequency, line adjustments and antenna tuning are unchanged, the relative values of line current will give an idea of the relative power going into the array. For example, twice the current will mean four times the antenna power, or an increase of 6 db. If any of these variables are changed, the values of line current cannot be compared. The idea is to get the maximum current under any given set of conditions. Don't try to compare these currents for different sets of conditions.

If an R.F. thermocouple ammeter is not available the next best device would be a low rating light bulb shunted along a section of one wire of the line, or a standing wave indicator placed across the line at a point where it can be watched while adjusting the transmitter (assuming an open wire line). See Section 8 and sketches of the standing wave indicating devices.

A field strength meter placed at a point where it picks up from the antenna only is a reasonable substitute for the above indicators, but is subject to reflected signals from people, cars, miscellaneous metallic objects, etc. If some one moves his car out of a nearby garage your reading will change.

12. Don't try to adjust the center impedence of an array by changing the spacing of the reflectors. You might do it, but at the expense of proper operation of the antenna. Every time a parasitic element spacing is changed a compensating change must be made in its length, to restore the correct phase lead or lag. Remember also that antenna adjustments will affect the load impedance as seen by the line; but that termination adjustments will not affect the antenna tuning or performance, unless by so doing you introduce some bad unbalance.

13. Don't build an antenna to be a "line terminator." Build it to be a radiator and concentrate on developing that function to the utmost. Apply your matching stub or bars afterward. The two functions are entirely separate.

A frequency shift from 144 to 148 mc is only a 3% change. Very few of these antennas, if any, "go out of tune" appreciably as a result of such a small frequency change. Slight changes of impedance, as well as magnified shifts of standing waves on the lines (which are usually several wavelengths long at 2 meters) produce changes at the transmitter which are all too frequently confused with a change of antenna properties. It is true that large diameter elements display smaller impedance variations for a given frequency shift, but is is doubtful that any distinct advantages will be gained by using larger than 1/4" O.D. tubing at 2 meters with the types of arrays discussed herein. Bigger tubing increases weight, wind resistance, wooden structure required and cost. For horizontally polarized arrays, particularly in regions where snow and ice are prevalent, either larger diameters or thicker wall tubing may be advantageous.

14. Don't EVER feed radiators in series with other radiators or through intermediate quarter-wave stubs. The elements will very seldom be in phase, or stay in the correct phase relationship. Their phase will change rapidly with frequency shifts; varying the antenna impedance, pattern and efficiency. Radiators should always be fed in parallel; that is, each driven element should be connected directly to the transmission line, or to a phasing line. The general methods of feeding multi-element arrays shown in these notes are believed to be the best and, in some instances the only suitable method; particularly with extended spacings.

15. The basic formula covering radiation from a wire shows that the amount of power radiated in any section is a function of the amplitude of the current flowing in the element at that point. In other words, most of the radiation is from the center section of a half wave dipole, and from the lower portion of a ground plane or of a center loaded whip. The far ends produce the fire and the current max sections do the work. Both are necessary though.

16. A good point to keep in mind is that you cannot achieve antenna gain without size. High gain does not come in small packages. Mere size, however, is not a cure-all. Don't get "element happy" and build super multi-element arrays until you know what you are doing. You may find that a lot of the elements are merely "going along for the ride." When horizontal polarization is used, such as on the 420 mc band, serious consideration should be given to the "Queen of the Antennas," the Rhombic. There are specific dimensions for rhombics for certain types of work, and the antenna will suffer if improperly designed, just as does any other piece of equipment. A properly designed rhombic needs no tuning adjustments whatsoever, and very little in the way of impedence adjustments, It will not be covered in these notes, but plenty of information is available elsewhere. It also must be of an appreciable size to be effective. Rotating a rhombic poses some tricky mechanical problems.

Remember this — A big antenna is not necessarily a good one. It may be improperly designed or tuned, in which case the energy may be wasted in a poor pattern or in high internal losses.

17. There is a certain difference of opinion as to the usefulness of adding directors to these multi-element arrays. They do give a slight increase in forward gain, and most likely improve the front to back ratio a bit, but at the expense of a nearly

doubled structure size and an appreciable increase in the Q of the array, both as regards tuning and feed point impedance. The difficulty of adjusting the array, and of holding it there with changes of frequency and weather conditions is increased.

For a given number of elements, broadside arrays usually produce more effective gain than end-fire arrays. However, a judicious combination of both types is desirable. A radiator and reflector (or even more parasitic elements) constitute an end-fire array. Two or more radiators fed in phase, either side by side, or end to end, constitute a broadside array. There should be one parasitic reflector for each driven element to obtain the most desirable characteristics. Such an array may not have the high front-to-back ratio of a Yagi, nor its sharp pattern, but it will maintain its high forward gain over a wider frequency range and is less susceptible to weather changes. This is known as the "rectangular" type of array, and is the type discussed in these notes.

18. Optimum radiator lengths, and broadside spacing between radiators, or groups of radiators are greater than the conventional half wave values. Optimum lengths are 0.625 wavelengths (measured at the proper VP on the tubing in use). Optimum broadside spacings are 0.65 wavelengths between adjacent elements, where there are no more than two rows (as in the 4 and 8 element arrays shown in these notes), and 0.75 wavelengths where there are 3 or more broadside rows (as exemplified in the 16 element arrays). These broadside values are based on the VP in free space and are not changed by different element diameters. Extended lengths cannot be used for parasitic elements. They must be of the proper tuned lengths. The center of each parasitic element must be placed directly behind the current maximum point on its associated radiator. This is illustrated in the 8 and 16 element arrays. The extended radiator lengths are not critical. Spacings between radiators and reflectors are one quarter wave, or 20 inches.

19. By judicious use of optimum lengths and spacings, and correct phasing and feeding methods, you can get the most out of a given number of elements. The table on Antenna Gains shows that a 16 element array with optimum dimensions has slightly more gain than a conventionally arranged 24 element array. Even though this extended 16 element array has a greater aperture than the 24 element structure it has less parts, weight, wind resistance and complexity of tuning.

Don't design antennas of this general type with units of 6 or 12 radiators. These are very unfortunate configurations to feed and are plagued by phasing and current distribution problems. Extended spacings in these units are particularly difficult to feed. A look at the Antenna Gain table will show, by interpolation, how little extra gain will be realized by the use of this number of elements. It is true that a 24 element array, extended both ways should have about 1.7 db gain over a similar arrangement of 16 elements, but the feeding problems would be serious. A 12 element beam would hardly be worth the trouble, when you can get what you want from an extended 8 or 16.

20. End-fire (out-of-phase) feedings of arrays is very difficult. Time-phasing by means of transpositions and odd length of phasing sections seem to give straight-forward results (on paper). Unfortunately the various reactions set up, and the different impedances present at junction points cause the power distribution between adjacent elements to differ by very large amounts.

21. Metallic supporting structures for multi-element rectangular arrays have some drawbacks. A metal pole up through the geometric center of a vertically polarized array seems to have no adverse effect on the operation. Metallic crossmembers at right angles to the plane of polarization of the elements cause little disturbance. However, complex structures with closed loops or isolated members, all of which might accidentally be tuned to or near resonance, can be detrimental to the pattern and gain.

Antennas of the general types shown in these notes do not need insulators to separate them from wooden supports, but long metallic sections in actual contact with end-driven elements can cause a serious distortion of the antenna properties due to re-distribution of currents on the radiators. Use wooden or other non-metallic support for direct connection with all elements of the arrays shown in these notes. High grade insulation at these points would be a waste of money, and add unnecessarily to the weight and wind resistance. Of course it is understood that the elements are all supported at current maximum (voltage node) points. In the Yagi type of array, the use of a metal support down the center of the array is perfectly satisfactory.

22. Here is a simple but effective way to check the proper position for connecting extended driven elements to the supporting structure.

> CAUTION — SAFETY FIRST — Be sure there is no high voltage D.C. or R.F. on the antenna before trying this.

Support the elements at approximately the points shown in the sketches; then place a standing wave indicator on the line at a point where you can see it from the antenna. Energize the antenna and, with a screwdriver, touch the extended element near the support points. The SWR indicator should show little or no change. Keep tapping the screwdriver on the element while moving it either side of your starting point. The indicating device should show an increased kick as you deviate from the proper location. The point of minimum kick is the place for the support. This will be the current maximum point on the element. Try placing the SWR meter at slightly different positions on the line if you don't get some reasonable indication. If you have no SWR indicator have someone watch the plate meter. The parasitic, tuned elements should be supported at their mid-points.

23. When tuning antennas, use a field strength meter placed from 100 to 300 feet to the REAR. First make a temporary termination on the main line to avoid possible large impedance changes at the transmitter during antenna adjustments. Then adjust the length of the parasitic elements for minimum signal to the rear. If only a reflector is used with each radiator, proceed as follows:

Cut the reflectors very slightly longer then you believe to be the right amount (the $64 question) and then energize the antenna on 8 to 10 different frequencies fairly equally distributed from 144-148 mc. Measure the signal strength to the rear for each frequency and plot these points on a graph. Draw a line through each point. If the elements are anywhere near the right length there will be a dip in the strength of the signal to the rear. The bottom of the dip will indicate the resonant frequency for the reflectors. If the dip is at too low a frequency a simple proportional calculation will indicate how much to cut off each reflector. With a little caution you can avoid cutting off too much and thereby spoiling a bunch of elements. Don't worry about tuning the front curtain. It will take care of itself. If you are using extended elements you can't resonate them anyway. The change in gain to the front will vary much more

slowly with frequency than does the indication to the rear. The chances are that you can't even plot the front curve sufficiently accurately because coupling adjustments at the transmitter may vary more than the actual forward output value of the antenna for each change in frequency. In other words, the gain to the front will change very little over the entire 4 mc bandwidth, and beyond.

If both reflectors and directors are employed, this variable-frequency method cannot be used. Instead the frequency must remain fixed and the parasitic elements pruned in groups, i.e., reflectors first until they are tuned, and then directors (or vice versa). Cut the reflectors in small increments and measure the signal strength to the rear for each new length. Adjust for minimum signal to the rear. Then do the same with the directors. This procedure is slightly wasteful of material, but is the only satisfactory method when several elements are to be checked simultaneously and two more separate groups of parasitic elements are used.
Re-terminate the main line when finished tuning. See also Note 12.

24. Don't use "shock excitation" when testing antennas, either for tuning or termination adjustments. This method gives unreliable answers. Energize the antenna in a normal manner, through the regular transmission line.

25. There is no such thing as an antenna that "won't load up." Anything that has resistance will accept power, if properly coupled. What it does with it after that is a function of how well it was designed and tuned. To get power into the antenna, suitable impedance matching must be accomplished between plate tank and line input and, to a lesser extent, correct impedance matching must be provided between line and antenna.

Any indication of loading at the transmitter is extremely unreliable insofar as its connection with antenna performance is concerned. Good antennas can load poorly and defective antennas can load excellently. There is no resemblance between this loading and either the antenna impedance or antenna tuning.

Most transmitter output circuits (which are mainly plain untuned links) are limited in their ability to cope with certain line impedances; or even with properly terminated lines; hence the famous expression — "she won't load up." See QST, August, 1947, Page 26, for some good information on this. A link tuning condenser is very desirable.

26. Since plate current is no criterion of power delivered to the line, some form of R.F. indication is vital. A thermocouple ammeter in the line is the best. A diode pick-up device across the line, connected to a milliameter is also good. If the crystal causes TVI, use it only for adjustments, then remove. A vacuum tube diode might be used. A field strength meter loosely coupled to the antenna is fairly good.

27. It is admitted that a ground plane antenna is easy to put up at home or on the car, and is omni-directional. However, Kraus points out in his book, Antennas, McGraw-Hill, Page 420, that unless the diameter of the ground plane is infinite (a big order) the antenna has a high angle of reflection, and considerable loss along the horizon. In other words it has even less output than the half wave reference dipole at the radiation angle we desire. At 40 meters this high angle of radiation may be of some use.

---This series will continue in the next issue and give antenna designs as well as the drawings referred to in the text.

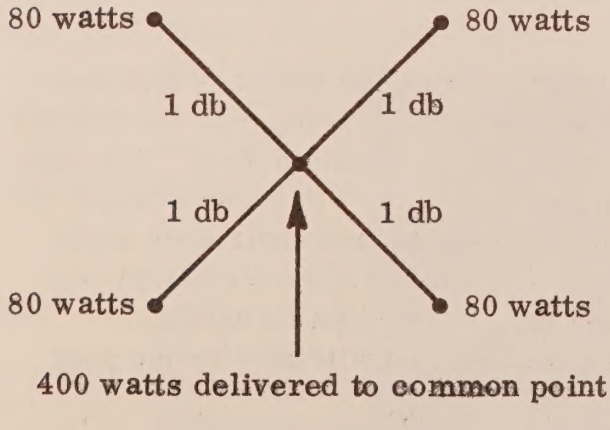
# Moonbounce Newsletter

by Victor A. Michael, W3SDZ
Box 345, Milton, Penna.

This month we'll consider the Yagi antenna for moonbounce. It is probably the best overall choice because the number of antenna elements is reduced, thus the feed harness losses can be reduced and the number of power splits and matches required is reduced. This also reduces another source of loss--phase distribution over the aperture. At 432 this can be a problem, since small errors in harness dimensions can introduce out of phase components. Generally you would like to hold things under ten degrees. If you look at a wavelength of coax at 432, you can get some idea of the problem. You must be very careful in your physical measurement--hold close tolerance. The problem with the yagi is that you must test your individual antenna element for gain and pattern to be sure it is working. Then you can duplicate it (with care).

As an example of what might be accomplished with the yagi on 432, let's look at a possible design. W2CCY built one of the most successful yagi arrays for 432 I know of. Cliff built a box of 4 yagis six feet square and worked not only Arecibo but WA6LET on the big dish at Stanford. His antenna had to be working. What was the magic? None. Cliff is just a careful worker who didn't take any shortcuts. The first thing he did was build one of the yagi antennas described in the Orr VHF Handbook (8 foot boom). Cliff found that he had to trim the driven element from 12 3/4" to 12 3/8" and take 1/16" off each of the directors. That doesn't sound like much, but it is at 432 with a high Q device like a yagi. I can't recall the exact number but Cliff found the original dimensions gave him an antenna resonant around 430 Mc. and by the time he got to 432 performance was way down. Think for a minute what the result would have been had Cliff not measured the individual yagi element for his array.

Now each individual element (Yagi) in the array has a gain over a dipole of 16.1 db. This means a gain of 18.2 db over an isotropic source. Now a box of four such as Cliff built could have a gain of 24.2 db, eight would buy you 27.2 db, 16 would be 30.2 db and 32, 33.2 db. True in the larger arrays, some loss will be introduced by the feed harness. How much loss? Well, it turns out that it is not as bad as one might think. The point to keep in mind is that the total loss of all the coax is divided up over the array because you are splitting the power up. The simple diagram below will show you a practical way to compute this.




Total power to common point-------400 watts
Total power radiated ----------320 "

Loss 80 watts

or 1 db overall loss, NOT 4 db loss.

Now the 1 db loss I used above was for simple figuring. In practice at 432 for instance RG 8 A/U foam coax has just under 4 db per hundred feet loss. Thus the approximate 4 feet necessary to tie together each bay of the quad yagi array just described would have a loss around .16 db. If you carry this all the way into the bigger arrays, you find out that one to one and a half db is all the loss you will suffer from this source of loss. If cost is not a factor, the larger and more expensive coax can be used to increase overall efficiency. I think you'll find that even the expensive coax is still cheaper overall than the price of materials for a dish of comparable gain. For instance, to come up with the same gain as the 32 unit yagi array mentioned above you would need a dish about 45 feet in diameter. The yagi array would be 42 by 18 feet, and many times lighter in weight. Also another factor to consider is the lower wind resistance of the yagi structure. To be sure there are other antennas that could be considered. We have looked at them all and what I've discussed appear to be the most practical for the amateur.

Now we come to the real problem in a moonbounce antenna, the mount. The best antenna in the world is worthless if you can't point it accurately at the moon. In this connection I can tell you a lot of things not to do, because I've been trapped by all the pitfalls the amateur usually falls into. You must first look at what objectives you want to fulfill. There are many tradeoffs you can make to simplify things. The two extremes are an antenna that is fully steerable to any point in the sky that the moon will pass thru to a fixed array aimed at one point in the sky where the moon will pass on a couple of days in each lunar month. Obviously the first case is the ideal and also the most difficult and expensive.

The suggestion has been made to me by K2CBA and others that for a fixed mount antenna or one with a limited movement, the design center should be that which is used by the Arecibo antenna. Generally this centers around a GHA of 66 degrees 45 minutes and a Dec. of North 12 degrees.

While I'm in favor of building a larger array with a limited movement versus building a smaller array that is fully steerable, I would argue for a mount that had at least 20 degrees or perhaps even more declination scan so that the antenna could be used on a greater number of days of the lunar month. I looked up the greatest amount of declination change the moon can have. It turns out that it is plus or minus 28.5 degrees from the celestial equator. This max. dec. occurs once every 18.5 years. We are nearing the peak declination right now. An hour or two of HA time would be enough for practical work if it centered around Arecibo and all the antennas in the world did likewise. Of course for VK3ATN in Australia we have another problem. Again I think it would be simpler to design an additional mount for work with the VKs when they are ready than building one fully steerable mount.

The most important consideration to keep in mind when building the mount is that the moving force should be applied at a mechanical advantage point. On my dish the drive was applied at the end of a small axle shaft. This is the wrong place to do it. The axle could be torqued by the wind more than 20 degrees. All gear slop will mean a large movement of the antenna in degrees. Cables pulling the antenna from outrigger arms appears to be one solution. Large pulley type wheels (ten feet or more diameter) centered on very heavy pipe axles turned by a closed cable system might be another. Jack screws and hydraulic cylinders offer additional ideas. You will have to use your ingenuity. 73 Vic.

# OPEN BANDS

by Marilyn Wiseman, K8ALO

A lot of contacts and new states resulted for many on 144 MHz, due to fine tropo openings and meteor showers during July and August. 50 MHz had good openings also. Thanks to all who sent reports in. Looking forward to yours. My address, Box 103, Petersburg, Ohio 44454.

144 MHz. TROPO

July 6 W5ML (La.) wrkd KØMQS (Ia.), WAØGFW (Kan.), KØIGN, WØLCN (Minn), WØEMS/Ø (Neb.) Art says signal strengths 559 to 579. Art got 2 new states from these QSOs. W9YYF (Ill.) wrkd W5HFV, W5ORH (Okla.), WØNXF (Neb.)

July 7 KØGEY (Iowa) wrkd W5WAX, W5ORH (Okla) K7UMC/5 (Ark.), K5WXZ (Tex.)

July 22 W9YYF (Ill) wrkd WØNXF, WØEMS/Ø Neb.

Aug 2 K1ABR (RI) wrkd K4QIF/4 (Va.) 400 mi.

Aug 5 W9YYF (Ill.) wrkd W5BAU/5 (Ark) state #28.

Aug. 6 K1ABR (RI) wrkd W8AEC (W.Va.) 350 mi, KØCER/4 (Va.) 420 mi.

Aug. 8 K2HLA (N.Y.) wrkd W8AEC (W.Va.), W4FJ, WØCER/4 (Va.) all cw. Dick says band opened from VE1 land south to western Va.

Aug. 11 W3OMY (Pa.) wrkd W1MEH , (Conn.)

Aug. 12 W9YYF (Ill.) wrkd W5BAU/5 (Ark.), W5HFV (Okla.).

Aug. 13 W9YYF (Ill.) wrkd K5WXZ (Tex) State #31.

Aug. 14 K1ABR (R.I.) wrkd VE3EZC (Ont.).

Aug. 15 K1ABR (R.I.) wrkd K4QIF (Va.), W8KAY (Ohio) 500 mi. W3OMY (Pa.) wrkd K1IED (Conn), W2ZFP (N.J.).

Aug. 16 K1ABR (R.I.) wrkd W8KAY (Ohio).

144 MHz AURORA

June 5 KØGEY (Ia.) wrkd K8UQA (Ohio).

June 6 KØGEY (Ia.) wrkd W8NUB, W8DGF (Ohio), K9AAJ (Ill.), WØMOX (Colo.)

June 25 WØNXF (Neb) wrkd W8KAY, W8NUB, K8AXU, K8DEO, W8DGF (Ohio), W9BRN, W9OJI, W9MAL (Ill.), WØLZO (Neb), WA9DOT (Wisc), KØIJK (Minn.), W5UGO (Okla), WØEYE (Colo.). Bob says that aurora openings this year have been so plentiful they're nothing unusual anymore. He wants to know where everyone is in the northwest areas. Bob now has 34 states in 10 call areas.

144 MHZ Meteor Scatter

July 27 W9YYF (Ill) wrkd W1AZK (N.H.) for state #27.

July 29 K1ABR (R.I.) wrkd KØMQS (Ia.) for state #26.

July 30 W1AZK (N.H.) wrkd W9YYF (Ill), WA9DOT (Wisc).

July 31 W1AZK (N.H. wrkd KØMQS (Ia.).

Aug. 10 K4EJQ (Tenn) wrkd WØNXF (Neb) for state #30. K1ABR (R.I.) wrkd W5GVE/4 (Ala.) State #27. K2HLA (N.Y.) wrkd W5BAU/5 (Ark) state #30.

Aug. 11 W9YYF(Ill) wr
state #28. K1

Aug. 12 K1HTV (Conn)
wrkd W5BAU/
wrkd WA5MF

Aug. 13 K2HLA (N.Y.
full 15 sec. b
(R.I.) wrkd W
K1HTV (Conn
(Ga.) state #

Aug. 14 K1ABR (R.I.) wrkd W9UNN (Ill.). K4EJQ (Tenn) wrkd W5BAU (Ark) state #31. K1HTV (Conn.) hrd W9UNN (Ill.).
Aug. 15 W1AZK (N.H. wrkd W5BAU (Ark) for first Ark.-N.H. QSO.

## COMMENTS ON METEOR SHOWERS

K2HLA (N.Y.) says this years Perseids showers seemed poor. Most of his m/s skeds were long haul, beyond 1200 miles, and he didn't hear anything from them. K1ABR in Rhode Island says "All here in the northeast seem to agree that Perseids was quite good this year. K1HTV (Conn.) had 35 hours of skeds made in advance with 11 stations in 8 states. He used a bit of automation by making tape loops with W xxx de K1HTV being played back on a tape recorder, which operated a keying relay. Rich has 32 states in 8 call areas. Best DX is 1252 miles.

432 MHz

June 11 K7ICW (Nev.) wrkd W6DQJ (Calif), K7RHK/7 (Utah).
June 25 K7ICW (nev.) hrd W6DQJ (Calif.
July 8 WØNXF (Neb) wrkd WØDRL (Kans) for first Nebr.-Kans. QSO on 432. Sigs were 599. This is state #5 for Bob in 3 call areas.
July 30 K7ICW (Nev.) wrkd K6HAA 185 mi. Sig 449.

## SKEDS WANTED

WØNXF (Nebr.) wants M/S skeds on 144 for all coming showers as described in QST May '67 Page 78. Bob has KW Johnson Thunderbolt. 144.022. 5218 Prescott, Lincoln.

W5ML (La.) wants M/S skeds with anyone within 1400 mi . Art has 30 sec. sequence on-off, about 30-35 wpm. 500 watts input to pair of 4x250Bs with 1250 volts on plates. W2AZL converter with 417A to NC183D. 14 el. Yagi up 70 ft. Box 301, Rt. 1 Vivian, La.

K4EJQ (Tenn.) wants skeds with Minn. and Kans on 144 via Leonid M/S. Also open for tropo skeds on Thurs and Sat. nights from mountain top QTH. Rig on mt. is 150 W. 13 element Yagi, HQ 150 rcvr. and 417A conv. Bunky Botts, rt. 2, box 72, Bristol, Tenn.

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EXPIRES WITH THIS ISSUE.

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